Determination of Composite Material Sensitivity to Permeability Depending Upon Lay-Up Configuration

Robert W. Carrigan/ED52
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The purpose of this study is to investigate how permeability is affected by fiber orientation (i.e., lamination sequence) at cryogenic temperatures for a given stress level. The test bottles will be designed to handle liquid hydrogen and fabricated using the automated filament-winding machine in the Productivity Enhancement Complex. The major objective of this research is to quantify the level of hydrogen permeability based upon a specific fiber orientation for a test bottle without a liner.

The effort to reduce launch vehicle weight significantly while still meeting mission objectives has led to the increasing use of high-modulus, high-strength composite materials for major structural elements. Under the National Aerospace Plane program, a rectangular composite liquid-hydrogen tank was designed and built to demonstrate that composite materials can be used to manufacture cryogenic tankage. However, one of the major problems that confronts the use of composite materials for linerless cryogenic tanks is permeability, which is further complicated when pressure and thermal cycling loads are taken into account.

A program has been initiated at MSFC to design, fabricate, and test a series of subscale test bottles to determine the effect that the lay-up configuration may or may not have regarding its permeability. The fabrication and testing of the bottles will be performed in four phases. The first phase will consist of 12 bottles—separated into four subsets of three bottles. Each group of three will be fabricated using the same material and fiber orientation. It is important to note that the materials used when comparing each group of three to each other may or may not be the same. Phases II, III, and IV will also consist of 12 bottles each. The bottles for phases II, III, and IV will not be fabricated until the bottles from phase I (or the previous phase) have been tested and the data analyzed.

This research will provide NASA with a valuable technology for the Reusable Launch Vehicle initiative. Once proven, the technology will provide a data point for acceptable permeability, directly benefiting the industrial partners working toward a reusable launch vehicle.

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